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THE COMPETITIVE ADVANTAGE OF NATIONS: AN APPLICATION TO ACADEMIA

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ABSTRACT

Within the field of bibliometrics, there is sustained interest in how nations "compete" in terms of academic disciplines, and what determinants explain why countries may have a specific advantage in one discipline over another. However, this literature has not, to date, presented a comprehensive structured model that could be used in the interpretation of a country's research profile and academic output. In this paper, we use frameworks from international business and economics to present such a model.

Our study makes four major contributions. First, we include a very wide range of countries and disciplines, explicitly including the Social Sciences, which unfortunately are excluded in most bibliometrics studies. Second, we apply theories of revealed comparative advantage and the competitive advantage of nations to academic disciplines. Third, we cluster our 34 countries into five different groups that have distinct combinations of revealed comparative advantage in five major disciplines. Finally, based on our empirical work and prior literature, we present an academic diamond that details factors likely to explain a country's research profile and competitiveness in certain disciplines.

INTRODUCTION

Within the international business discipline, scholars have long reflected upon what industries and nations specialize in, and what the explanation behind their international competitive advantages might be (see, e.g. Porter, 1990; Grant, 1991; Rugman and D'Cruz, 1993). Within the field of bibliometrics, there is sustained interest in how nations "compete" in terms of academic disciplines, and what determinants explain why countries may have a specific advantage in one discipline over another (see, e.g., Frame, 1977; Braun et al., 1995a/b; BIE, 1996; Kozlowski et al., 1999; Garg, 2003; Horta and Veloso, 2007). Clearly academic publishing is not a traditional competitive zero-sum game, i.e. if academics from one country publish in a particular journal, it doesn't mean academics from other countries cannot publish there. However, there is certainly an element of competition involved as most journals have page limits and not all papers can be published[1]. Therefore, one can assume that when a country publishes more in certain disciplines in comparison to others, it has a competitive advantage in these disciplines.

Understanding academic competitiveness matters, since academic output has risen worldwide over the past two decades, and higher-education institutions put increasing emphasis on the research performance of their academic staff, which in turn is a way to assess institutions' competitiveness in various academic fields. In this paper, we consider country-level competitiveness in various disciplines, with the understanding that it is higher education institutions that compete and engage in specific actions to maintain their competitive position (Bertsch, 2000).

There is a large number of quantitative analyses of research productivity. Yet very few engage in a *comparative* analysis of how academically competitive individual countries are in specific disciplines in relation to others, and, importantly, what might explain this competitive advantage. Studies that have compared countries include reports aimed at aiding policy-makers (e.g. May, 1997; King, 2004; FWF, 2007), or broad-ranging cross-country and cross-discipline studies that provide descriptive comparisons (e.g. Braun et al., 1995a/b; Yang et al., 2012), rather than a more systematic analysis of elements that might constitute a country's competitiveness in individual fields of study.

Existing studies have identified some determinants explaining variation in research output and quality. The main determinants put forward include country size, level of economic development (GDP or GDP per capita) (May, 1997; King, 2004; Rousseau and Rousseau, 1998; Inonu, 2003), financial investments (public expenditure for R&D) (May, 1997; King, 2004; Zhou and Leydesdorff, 2006; FWF, 2007), competitive promotion of basic research such as knowledge infrastructure (for instance, the example of CERN would explain Switzerland's success for publications in physics), and incentive structures within research institutions (Almeida et al., 2009). These determinants centre on selected economic and institutional considerations, and the literature has not, to date, presented a comprehensive structured model that could be used in the interpretation of a country's academic competitiveness.

In this paper, we use frameworks from the international business and economics disciplines to present such a model. Our study makes four major contributions. First, we include a very wide range of countries and disciplines, explicitly including the Social Sciences, which unfortunately are excluded in most bibliometrics studies (see also Harzing, 2013). Second, we apply theories of revealed comparative advantage and the competitive advantage of nations to academic publishing. Third, we cluster our 34 countries into five different groups that have distinct combinations of revealed comparative advantage in five major disciplines. Finally, based on our empirical work and prior literature, we present an academic diamond that details factors likely to explain a country's research profile and competitiveness in certain disciplines.

LITERATURE REVIEW

In this paper, we apply theoretical concepts from the international business and economics literatures to academic publishing. In doing so, we follow the lead of Lockett and Williams (2005) and Cro-

[1] One could argue that with the increase of open access publishing, journal space is no longer a limitation. However, legitimate open access journals are still selective in terms of the papers they accept. Further, many of them are not included in the Web of Knowledge, the database used in this study. Moreover, we are considering 2002-2012, a period in which OA journals were still fairly rare in most fields. Hence, we do not think the trend to OA publishing has a large impact for the current study.

nin and Meho (2008), who both used the balance of trade metaphor to study citation patterns between disciplines. Like these authors, our analysis is reflective and descriptive rather than prescriptive, it does not imply a recommendation of which disciplines or research areas countries *should* focus on. Although this could well be a natural extension of our study, this is the domain of science policy (see e.g. Irvine & Martin, 1984), which is not the focus of our current study.

The international economics literature has long established means to compare how well countries perform internationally for specific industries/products. The concept of Revealed Comparative Advantage (RCA) is used to highlight where countries benefit from an advantage and specialize in terms of trade (Maneschi, 2008). It was first developed by Balassa in 1965 and compares a country's share of world exports in a sector to its share of exports overall. It shows whether a country specializes in a specific product relative to other countries that export the same product. "The comparison to world exports in the formula for RCA serves the useful purpose of normalizing the trade data for the size of sectors and countries, which otherwise might give misleading impressions of the importance of a sector and country in international trade" (OECD, 2011:32). The concept of RCA can also be useful in the analysis of scientific discipline across a large number of countries, as it can be used with other data as a guide to what causes actual scientific output patterns, and whether these truly constitute comparative advantage or not.

Another useful theory can be found in the international business literature. Porter's diamond (Porter, 1990), which builds on Porter's earlier frameworks on competitive strategy (Porter, 1980) and competitive advantage (Porter, 1985) has become a well-established framework to analyse the competitive advantage of nations (Ketels, 2006). In his seminal 1990 book, Porter develops the concept, bridging the gap between strategic management and international economics (Grant, 1991; Pitelis, 2009:101). The diamond suggests that national competitive advantage depends on four determinants, represented as a diamond; namely, factor costs, domestic demand, related and supported industries in the home country, and amount of rivalry in the home country between leading firms/institutions by sector. The complete model includes two additional constructs. Change events (such as technological discontinuities, global shifts or political decisions by foreign governments) matter because they create discontinuities that allow shifts in competitive position (Porter, 1990). Government is crucial because it can shape all four determinants. The four determinants and two additional constructs interact as a system, with identified hierarchies amongst factors. For instance, Porter distinguishes between basic factors (natural resources, climate, location and demographics), and advanced factors (communications infrastructure, sophisticated skills, research facilities). Advanced factors are the most important to competitive advantage, as they are not factors for which supply depends upon exogenous endowment, and thereby result from investments by individuals, companies and governments.

There were two main areas of critique relating to the model. Firstly, authors have suggested that for countries with supra-national institutions, the diamond may need to be complemented with that of neighbouring countries because of a common set of government regulations, institutions, judicial and administrative procedures (Rugman and D'Cruz, 1993). Secondly, it is to be noted that a weakness lies in the diamond's ambiguity over signs of relationship, complexity of interaction, and dual causation, all of which make predictions unclear (Grant, 1991:542). Nonetheless, the diamond has proved useful in explaining international competitiveness of countries and industries (see for instance Nachum, 1998; Nair et al, 2007 or Dögl and Holtbrügge, 2010), and it is used in this paper with an application to academia.

In the diamond, higher education is considered an advanced factor, and as such represents a source of competitive advantage. In this paper, the focus is on a country's competitive advantage in academia, and we propose using research output as a measure of unique advantage arising from research. As such, it is higher education institutions, just like firms and industries in Porter's model, are committed to internal investment in the products/processes and skills needed to continuously upgrade their sources of advantage (Bertsch, 2000), but the competitive potential is dependent upon the configuration of factors in the diamond. Countries can upgrade their competitive position when they develop the capability to compete successfully in new segments and/disciplines. In the process of development, a country can slide backward if it experiences falling rivalry, lagging factor creation, declining motivation or eroding demand (Porter, 1990:562). In this paper, longitudinal data (1994-2004 and 2002-2012) helps to identify whether a country's research profile evolves over time.

To conclude, in this article we utilize the *revealed comparative advantage* to identify country's research profile and competitive position in various disciplines, and subsequently apply Porter's diamond of international competitiveness to discuss our results on academic research output in 34 countries across two time periods. The aim is to compare countries' research profiles and competitiveness in selected disciplines. For this, we assess whether countries can be clustered into coherent groups with comparable profiles and what may explain these profiles.

METHODS: DATA SOURCE AND MEASURES

Research output was measured by the number of papers published by a country. As this introduces a bias towards highly populated countries, we also included the number of papers published per 100,000 inhabitants. Population data were sourced from the CIA World Factbook (July 2004/2012 estimates). Publication data were sourced from the ISI Web of Knowledge's Essential Science Indicators (ESI). The Essential Science Indicators provide information on the world's most productive scientists, institutions and countries in all of the Web of Knowledge disciplines. In this paper we focus on country-level analyses. Country information is based on the affiliation of the authors of the published papers. This means that if a paper has multiple authors from different countries, it will count towards the number of publications for each of these countries. However, each paper counts only once for a particular country, even if there are several authors from that country.

We collected country level data at two points in time, in 2004 and 2012. At the time of our data collection, the ESI indicators covered a ten-year plus six-month period, January 1, 1994–June 30, 2004 and January 2002–June 30 2012. The Web of Knowledge covers 22 disciplines. The multidisciplinary category was excluded from our study, as there were only eleven countries with more than 500 papers in this category, so 21 disciplines remained. To address the problem that most bibliometric studies exclude Social Sciences (see also Harzing, 2012), we included Social Sciences General (e.g. Education, Sociology, and Political Sciences), Business & Economics, and Psychology & Psychiatry as three of the 21 disciplines.

In order to keep data collection and analysis manageable, we included the top-20 countries in terms of papers published for each discipline and also included these countries for other disciplines, even if they were not listed in the top-20 for these disciplines. As a result, 34 countries were covered in our overall analysis for 1994-2004. For the 2002-2012 period, we included the same 34 countries in our analysis. It is important to note that although we obviously only include a sub-set of the world's countries, the countries that *are* included in our study are responsible for 90-95% of the total number of papers included in ESI in each discipline. For the remaining countries, the number of papers published in the individual disciplines is so small that including them would be likely to lead to highly unstable and idiosyncratic results.

It is well known that ISI coverage of research output varies by discipline (see e.g. Harzing and van der Wal, 2008). In particular, we find low ISI coverage in certain areas of Engineering as well as in the Social Sciences (Moed, 2005, Nederhof, 2006). In Engineering, conference proceedings, which are covered only to a limited extent by ISI, are important publication outlets. However, since this is true for all countries, it should not necessarily bias comparison *between* countries. In the Social Sciences, low ISI coverage is caused by the fact that ISI over-represents English language journals (Archambault et al. 2006), whereas much of the output in the Social Sciences has traditionally appeared in books and national journals in the local language (Nederhof, 2006). Therefore, although the exclusive use of ISI data might not be appropriate to analyse research productivity for individual academics in the Social Sciences, we decided that coverage was sufficient enough to include the three Social Science categories (Social Sciences General, Economics & Business, and Psychology & Psychiatry) in our broad, country-level, analyses.

To assess a country's comparative advantage in a particular discipline, we compared the number of papers for a particular country in a particular discipline with the total number of papers in that discipline for the 34 countries included in the analysis.[2] This is an simple modification of the international economics concept of RCA to academic outputs and refers to the share of a country's papers in a given field relative to the share of world papers in that field. We subtracted 1 from the resulting value, so that values above zero reflect comparative advantage and values below zero comparative disadvantage. So for instance, the USA has published 17.8% of the papers in Agricultural Sciences, as against 24.5% of the papers in all disciplines, and hence has a comparative *dis*advantage in this field. The extent of the disadvantage is 27%. This metric has been applied in a large number of bibliometric studies, starting with the analysis by Frame (Frame, 1977) under the name "Activity Index".[3] However, few of these studies provide recent information on a large number of countries and none include the Social Sciences.

Our 21 disciplines and 34 countries present a wealth of information. However, in order to apply our academic diamond analysis, this information needed to be reduced to a more manageable format. We therefore first grouped our 21 sub-disciplines into five major discipline clusters. We are not the first to attempt such a discipline grouping. In 1996, the Australian Bureau of Industry Economics report identified three disciplinary clusters, Environmental Sciences, Medical Sciences and Engineering. Zhou et al. (2012) collapsed their fourteen disciplines into three major areas: Life Sciences, Physical Sciences and Environmental Sciences. Our study combines these two classifications to provide four categories, and adds Social Sciences as a fifth category.

[2] As one of the reviewers rightly pointed out, publications reflect crude market share, not downstream value (impact, i.e. citations) and one could question whether this really constitutes competitive advantage. However, as citations are even more skewed than publications, using citations as a measure of competitive advantage could lead to substantial distortions for countries with few publications. In that case, even one highly cited paper that is authored mostly by academics from other countries, but has just one author from the country in question could create a competitive advantage in citations for the latter country. Furthermore, citations are biased towards Western developed countries and are less closely linked a country's authors (and hence a country's competitive advantage factors) than publications. Hence, we feel that in the context of our papers, publications are a better measure than citations.

[3] Recently, the AI index has been critiqued by Rousseau & Yang (2012). The authors show that the activity index has some theoretical flaws that could lead to counterintuitive results, such that an increase in the production of articles in a field could lead to a decrease in the AI. However, in practice these flaws do not seem to have serious consequences as the increase must take unrealistically high values (often more than the world production of articles in one year) to create problems.

- **Social Sciences**: Social Sciences, Psychiatry & Psychology, Economics & Business
- **Physical Sciences:** Physics, Chemistry, Mathematics, Space Science
- **Engineering Sciences:** Engineering, Computer Sciences, Materials Science
- **Environmental Sciences:** Environment & Ecology, Geosciences, Plant & Animal Sciences, Agricultural Sciences
- **Biomedical Sciences:** Clinical Medicine, Immunology, Molecular Biology, Neuroscience, Biology & Biochemistry, Microbiology, Pharmacology & Toxicology.

We subsequently averaged our RCA measures for each of these five main disciplines and conducted a hierarchical cluster analysis to group our countries based on their revealed comparative advantage in these five major disciplines.

RESULTS

DESCRIPTIVE DATA

We first report descriptive data on the ranking of countries in terms of the number of papers and compare these data for the two time-periods. Table 1 includes results for both 2002-2012 (top line roman font for each country) and 1994-2004 (bottom line italic font). It ranks countries by the total number of papers published in *all* disciplines in the two 10.5-year periods. In column 4, it corrects this output for population size by presenting the number of papers published per 100,000 inhabitants. In order to assess a country's competitive advantage in a particular area, Table 1 lists the relative top and bottom three disciplines in each country.

As Table 1 shows, nearly two-thirds of the research output listed in the Web of Knowledge comes from English-speaking North America (USA/Canada), China, Japan and the four largest European countries (UK[4], France, Germany, Italy). However, this should be seen in relation to the very large population in these countries. If we look at the number of papers published per 100,000 inhabitants, it is the smaller Western countries (Scandinavian countries, Netherlands, Belgium, Israel, Switzerland, New Zealand, Australia) that appear at the top, moving up in rank an average number of 13 places. In contrast, China drops from #2 to #33 when population size is taken into account, India drops from #11 to #34, Russia from #13 to #28, and Brazil from #15 to #31 – even the USA drops from #1 to # 17.

When comparing 1994-2004 and 2002-2012, we see that apart from Russia – which shows a 4% decline – and Ukraine – a very modest 3% increase – all countries have substantially increased their number of papers published. The larger scientifically-established countries, such as Japan, USA, UK, Germany and France show relatively modest increases, between 8% and 22%. The productivity of the smaller countries of Sweden and Israel also increased at this magnitude. As a result, most of these countries dropped one or two places in ranking. The other small countries (Canada, Netherlands, Switzerland, Belgium, Denmark, Austria, Finland, New Zealand, and Hungary) increased their output between 30% and 40%, but have generally lost ground in terms of ranking because of the much stronger growth in other countries. Italy is also in this category.

Countries in Asia show the highest proportional increase: India (78%), Taiwan (97%), Singapore (115%), South Korea (145%) and China (258%). China's very strong growth means that it now ranks 2nd only to the USA in terms of papers published, an increase from 9th only eight years before. Like-

[4] The Essential Science indicators list England, Scotland, Wales and Northern Ireland as separate countries. Although this is strictly speaking correct, this underestimates the research impact that the United Kingdom as a whole has. We therefore aggregated the data of these four countries to represent the sovereign state of the UK.

wise, South Korea, Taiwan and Singapore have moved up four or five places, whilst India has increased its rank from #13 to #11. Brazil (136%) and Turkey (189%) show similarly high levels of growth in the number of papers published and have increased their rank by four and six places respectively. In between are a mixed group of countries that show increases of around 50% (Australia, Norway, Argentina, South Africa), around 65% (Spain, Poland) and 80-90% increase (Greece, Ireland).

Between 2004 and 2012, the country ranking in terms of number of papers per 100,000 inhabitants has remained more stable. However, the differential growth rates in terms of papers published mean that many of the scientifically-established countries, such as Japan, USA, UK and Canada, see their rank in this category drop 3-5 places. In the top-10, several smaller countries – Denmark, Finland, the Netherlands and Australia – all climb a place, now ranking respectively #3, #4, #6 and #8. Norway gains no less than 3 places in the top-10, rising from #8 to #5. Losers in the top-10 are Israel, dropping from #3 to #7, and the UK, dropping from #6 to #9. Outside the top-10, Taiwan, Turkey and Singapore have all risen by 4 places.

Table 1: Ranking of research output and relative top/bottom 3 disciplines by country 2002-2012 (1994-2004 data in italics on second line)

Rank	Country	No. of papers	Papers/100,000 Inhabitants (rank in brackets)	Top 3 disciplines (highest)	Top 3 disciplines	Top 3 disciplines	Bottom 3 disciplines	Bottom 3 disciplines	Bottom 3 disciplines (lowest)
1	USA	3,131,600	998 (17)	Social Sciences	Psychiatry & Psychology	Economics & Business	Physics	Chemistry	Material Sciences
1	*+16%*	*2,688,502*	*917 (13)*	*Social Sciences*	*Psychiatry & Psychology*	*Economics & Business*	*Chemistry*	*Physics*	*Material Sciences*
2	China	960,736	72 (33)	Material Sciences	Chemistry	Mathematics	Economics & Business	Social Sciences	Psychiatry & Psychology
9	*+258%*	*268,347*	*21 (33)*	*Material Sciences*	*Chemistry*	*Mathematics*	*Social Sciences*	*Immunology*	*Psychiatry & Psychology*
3	UK	888,506	1409 (9)	Social Sciences	Economics & Business	Psychiatry & Psychology	Chemistry/Mathematics	Agricultural Sciences	Material Science
2	*+20%*	*742,455*	*1232 (6)*	*Social Sciences*	*Economics & Business*	*Psychiatry & Psychology*	*Chemistry*	*Physics*	*Mathematics*
4	Germany	813,382	1000 (16)	Space Science	Physics	Neurosciences	Agricultural Sciences	Engineering	Social Sciences
4	*+22%*	*664,912*	*807 (15)*	*Physics*	*Space Science*	*Chemistry*	*Environment & Ecology*	*Economics & Business*	*Social Sciences*
5	Japan	778,174	611 (24)	Material Sciences	Pharmacology & toxicology	Physics	Economics & Business	Psychiatry & Psychology	Social Sciences
3	*+8%*	*721,712*	*567 (19)*	*Material Sciences*	*Pharmacology & toxicology*	*Chemistry*	*Psychiatry & Psychology*	*Economics & Business*	*Social Sciences*
6	France	580,871	885 (18)	Mathematics	Space Science	Geosciences	Economics & Business	Psychiatry & Psychology	Social Sciences
5	*+19%*	*487,101*	*806 (16)*	*Mathematics*	*Space Science*	*Geosciences*	*Economics & Business*	*Psychiatry & Psychology*	*Social Sciences*
7	Canada	474,206	183 (12)	Psychiatry & Psychology	Environment & Ecology	Social Sciences	Chemistry	Material Sciences	Physics
6	*+33%*	*357,487*	*1100 (9)*	*Environment & Ecology*	*Psychiatry & Psychology*	*Geosciences*	*Chemistry*	*Material Sciences*	*Physics*
8	Italy	452,129	738 (22)	Space Science	Neurosciences	Mathematics/Pharma & Toxicol.	Material Sciences	Psychiatry & Psychology	*Social Sciences*
7	*+41%*	*320,190*	*552 (20)*	*Space Science*	*Neurosciences*	*Pharmacology & Toxicology*	*Economics & Business*	*Psychiatry & Psychology*	*Social Sciences*
9	Spain	365,246	777 (21)	Agricultural Sciences	Animal Sciences	Mathematics	Geosciences	Immunology	Social Sciences
10	*+67%*	*219,181*	*544 (21)*	*Agricultural Sciences*	*Mathematics*	*Chemistry*	*Economics & Business*	*Psychiatry & Psychology*	*Social Sciences*
10	Australia	323,377	1469 (8)	Social Sciences	Psychiatry & Psychology	Env. & Ecology /Eco & Bus	Material Sciences	Chemistry	Physics
11	*+49%*	*216,327*	*1086 (10)*	*Plant & Animal Science*	*Agricultural Sciences*	*Environment & Ecology*	*Material Sciences*	*Chemistry*	*Physics*
11	India	318,288	26 (34)	Agricultural Sciences	Chemistry	Material Sciences	Social Sciences	Economics & Business	Psychiatry & Psychology
13	*+78%*	*178,407*	*17 (34)*	*Agricultural Sciences*	*Chemistry*	*Material Sciences*	*Social Sciences*	*Economics & Business*	*Psychiatry & Psychology*
12	South Korea	309,391	633 (23)	Material Sciences	Computer Sciences	Engineering	*Space Science*	*Social Sciences*	*Psychiatry/ Psychology*
16	*+145%*	*126,315*	*260 (25)*	*Material Sciences*	*Computer Sciences*	*Engineering*	*Space Science*	*Social Sciences*	*Psychiatry/ Psychology*
13	Russia	265,566	186 (28)	Physics	Geosciences	Chemistry	Psychiatry & Psychology	Immunology	Economics & Business
8	*-4%*	*276,368*	*192 (27)*	*Physics*	*Geosciences*	*Chemistry*	*Economics & Business*	*Pharmacology & toxicology*	*Immunology*
14	Netherlands	265,474	1587 (6)	Psychiatry & Psychology	Economics & Business	Immunology	Physics/Chemistry	Mathematics	Material Sciences
12	*+35%*	*197,163*	*1208 (7)*	*Immunology*	*Psychiatry & Psychology*	*Space Science*	*Physics*	*Mathematics*	*Material Sciences*
15	Brazil	232,151	116 (31)	Agricultural Sciences	Plant & Animal Sciences	Pharma & Toxicology	Computer Science	Psychiatry & Psychology	Economics & Business
19	*+136%*	*98,572*	*54 (32)*	*Agricultural Sciences*	*Plant & Animal Sciences*	*Microbiology*	*Social Sciences*	*Economics & Business*	*Psychiatry & Psychology*
16	Taiwan	193,990	835 (19)	Engineering	Computer Science	Material Sciences	Neuroscience	*Psychiatry & Psychology*	*Space Science*
20	*+97%*	*98,271*	*432 (23)*	*Engineering*	*Computer Science*	*Material Sciences*	*Social Sciences*	*Space Science*	*Psychiatry & Psychology*
17	Switzerland	192,346	2427 (1)	Immunology	Geosciences	*Molecular Biology*	Materials Science	Mathematics	Social Sciences
15	*+38%*	*139,832*	*1877 (1)*	*Immunology*	*Molecular Biology*	*Physics*	*Mathematics*	*Psychiatry & Psychology*	*Social Sciences*

18	Sweden	183,825	2019 (2)	Immunology	Environment & Ecology	Biology & Biochemistry	Computer Sciences/Chemistry	Agricultural Sciences	Mathematics
14	+19%	154,107	1715 (2)	Immunology	Environment & Ecology	Neuroscience	Computer Sciences	Space Science	Mathematics
19	Turkey	166,912	209 (27)	Agricultural Sciences	Clinical Medicine	Plant & Animal Sciences	Molecular Biology	Immunology	Space Science
25	+189%	57,831	84 (31)	Clinical Medicine	Agricultural Sciences	Pharma & Toxicology	Social Sciences	Molecular Biology	Space Science
20	Poland	162,650	423 (26)	Chemistry	Physics	Mathematics	Economics & Business	Psychiatry & Psychology	Social Sciences
18	+65%	98,602	255 (26)	Chemistry	Physics	Mathematics	Economics & Business	Social Sciences	Psychiatry & Psychology
21	Belgium	145,727	1396 (11)	Microbiology	Agricultural Sciences	Plant & Animal Sciences	Social Sciences	Geosciences	Material Sciences
17	+43%	102,001	986 (12)	Microbiology	Plant & Animal Sciences	Pharma & toxicology	Psychiatry & Psychology	Geosciences	Social Sciences
22	Israel	113,640	1497 (7)	Mathematics	Psychiatry & Psychology	Computer Sciences	Agricultural Sciences	Geosciences	Material Sciences
21	+18%	96,652	1559 (3)	Mathematics	Computer Sciences	Psychiatry & Psychology	Material Sciences	Pharmacology & toxicology	Geosciences
23	Denmark	102,858	1855 (3)	Environment & Ecology	Agricultural Sciences	Immunology	Engineering	Mathematics	Material Sciences
22	+31%	78,287	1446 (4)	Environment & Ecology	Agricultural Sciences	Plant & Animal Sciences	Psychiatry & Psychology	Social Sciences	Material Sciences
24	Austria	100,576	1224 (14)	Clinical Medicine	Immunology	Computer Sciences	Psychiatry & Psychology	Agricultural Sciences	Social Sciences
24	+41%	71,115	870 (14)	Clinical Medicine	Immunology	Computer Sciences	Economics & Business	Psychiatry & Psychology	Social Sciences
25	Finland	91,737	1743 (4)	Environment & Ecology	Computer Science	Plant & Animal Science	Mathematics	Material Sciences	Chemistry
23	+26%	72,967	1399 (5)	Environment & Ecology	Clinical Medicine	Agricultural Sciences	Geosciences	Mathematics	Chemistry
26	Greece	88,700	824 (20)	Computer Science	Agricultural Sciences	Engineering	Psychiatry & Psychology	Neuroscience	Social Sciences
27	+81%	49,108	461 (22)	Computer Science	Engineering	Agricultural Sciences	Psychiatry & Psychology	Neuroscience	Social Sciences
27	Norway	77,114	1638 (5)	Geosciences	Environment & Ecology	Plant & Animal Sciences	Physics	Chemistry	Material Sciences
26	+53%	50,454	1103 (8)	Geosciences	Environment & Ecology	Plant & Animal Sciences	Chemistry	Material Sciences	Physics
28	Singapore	72,233	1349 (13)	Computer Science	Engineering	Material Sciences	Agricultural Sciences	Geosciences	Space Science
33	+115%	33,668	773 (17)	Computer Science	Engineering	Material Sciences	Agricultural Sciences	Geosciences	Space Science
29	Argentina	61,131	145 (29)	Agricultural Sciences	Plant & Animal Sciences	Microbiology	Economics & Business	Computer Sciences	Psychiatry & Psychology
30	+51%	40,379	103 (28)	Agricultural Sciences	Plant & Animal Sciences	Microbiology	Computer Sciences	Social Sciences	Psychiatry & Psychology
30	New Zealand	60,923	1408 (10)	Agricultural Sciences	Environment & Ecology	Plant & Animal Sciences	Material Sciences	Space Science	Physics
28	+41%	43,309	1084 (11)	Agricultural Sciences	Plant & Animal Sciences	Environment & Ecology	Material Sciences	Space Science	Physics
31	South Africa	58,442	120 (30)	Plant & Animal Sciences	Environment & Ecology	Social Sciences	Computer Sciences/Physics	Molecular Biology	Neuroscience
32	+54%	37,931	89 (30)	Plant & Animal Sciences	Environment & Ecology	Geosciences	Molecular Biology	Physics	Neuroscience
32	Hungary	51,891	521 (25)	Mathematics	Agricultural Sciences	Neurosciences	Social Sciences	Psychiatry & Psychology	Economics & Business
31	+29%	40,118	400 (24)	Mathematics	Agricultural Sciences	Chemistry	Economics & Business	Social Sciences	Psychiatry & Psychology
33	Ireland	50,017	1059 (15)	Agricultural Sciences	Microbiology	Social Sciences	Material Sciences	Chemistry	Geosciences
34	+90%	26,316	663 (18)	Agricultural Sciences	Psychiatry&Psychology	Economics & Business	Chemistry	Physics	Molecular Biology
34	Ukraine	44,001	98 (32)	Material Sciences	Physics	Mathematics	Clinical Medicine	Psychiatry & Psychology	Social Sciences
29	+3%	42,779	90 (29)	Material Sciences	Physics	Chemistry	Economics & Business	Psychiatry & Psychology	Social Sciences

Blue italics: Discipline that was included in the bottom-3 in 2004, but no longer is in 2012

Red italics: Discipline that was included in the top-3 in 2004, but no longer is in 2012

Blue bold: Discipline that was not included in the top-3 in 2004, but is in 2012

Red bold: Discipline that was not included in the bottom-3 in 2004, but is in 2012

REVEALED COMPARATIVE ADVANTAGE

Table 1 also lists each country's top-3 and bottom-3 disciplines. When comparing the top/bottom three disciplines between 2002-2012 and 1994-2004, the results are fairly stable. Nine countries show identical patterns across the two periods, whilst another thirteen see only one of their six top or bottom disciplines change. So for twenty-two of the thirty-four countries there are very few changes. Overall, the disciplines that showed the largest changes over time were the three disciplines that are part of the Social Sciences: Social Sciences General, Psychology & Psychiatry, and Economics & Business. Seven out of the twenty-one new top-three disciplines and fourteen out of the twenty-three disappearing bottom-three disciplines were part of the Social Sciences. This is likely to be caused both by increased ISI coverage in these fields and by the increase of publications by academics in non-Anglophone countries in English-language journals. Given that only three of the twenty-one disciplines included in our study are in the Social Sciences, the fact that nearly half of the changes are in this category clearly illustrates the important changes that are taking place in the publication patterns in these disciplines.

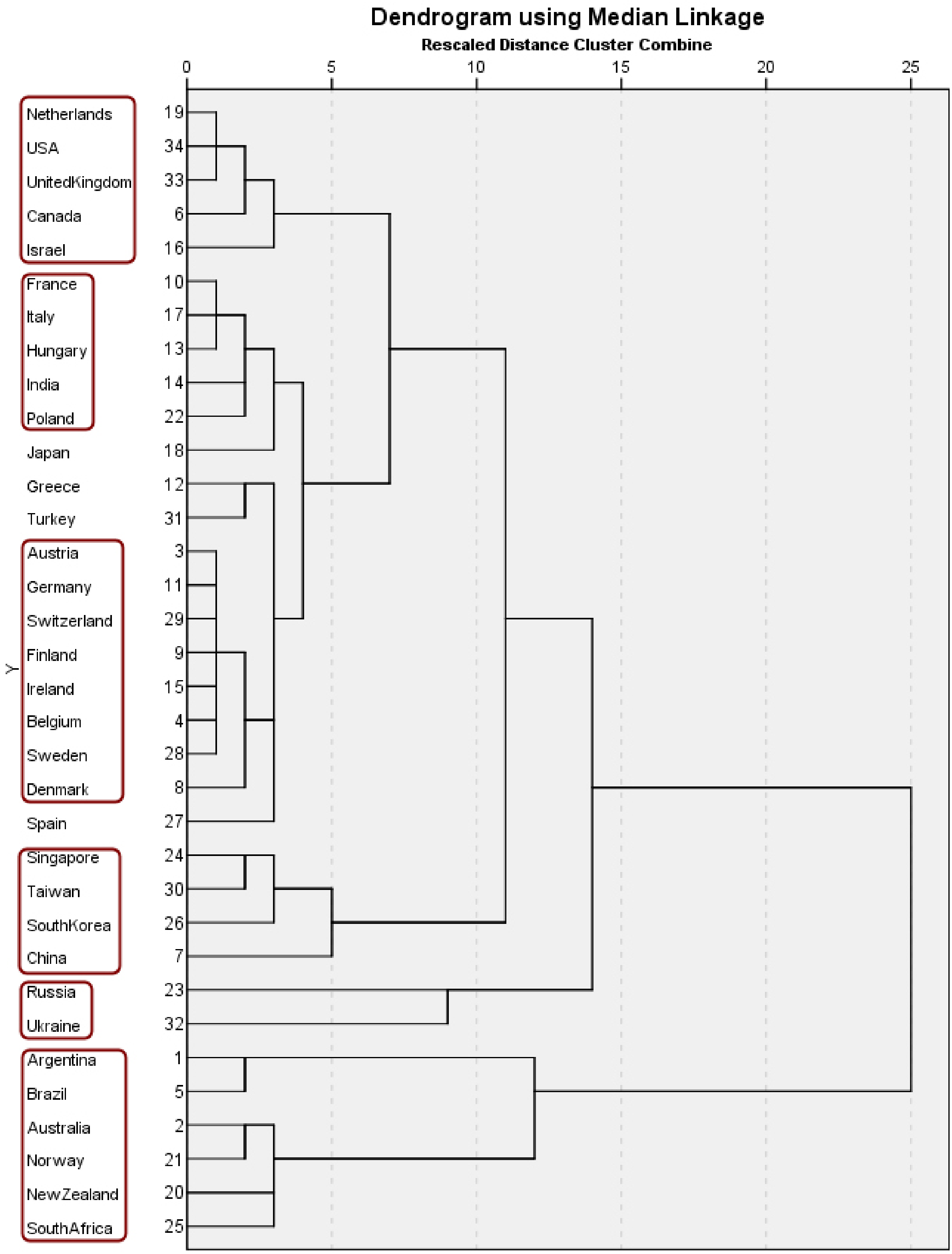
Many countries present a fairly coherent pattern. For instance, the USA shows a high revealed comparative advantage in the three Social Sciences and a low revealed comparative advantage in the Physical and Engineering Sciences. China shows the complete reverse pattern. Countries such as New Zealand and Norway have a strong RCA in Environmental Sciences. Other countries show more mixed patterns. However, just looking at the top and bottom 3 disciplines might hide significant patterns that appear just below or above the top/bottom 3. Hence, our next step was to cluster our 34 countries based on the five major disciplinary clusters: Social Sciences, Physical Sciences, Engineering Sciences, Environmental Sciences and Biomedical Sciences.

Figure 1 present the dendogram of our hierarchical cluster analysis, whereas Table 2 reports the relative comparative advantages and disadvantages in the five major disciplinary clusters for each cluster of countries. Almeida et al. (2009) conducted a similar cluster analysis, although they based their analysis on citations rather than publications and included European countries only. They concluded that geography was the major factor explaining similarities in research profiles between countries. However, this might well be partly caused by their focus on Europe only. Almeida et al. called for future analyses that include other indicators, such as social, economic and historical. Our analysis based on the academic diamond partly responds to this call.

Starting from the top of the figure our first cluster includes the more populous Anglophone countries (USA, UK, Canada), the Netherlands and Israel. Table 2 shows that this group has its main RCA in the Social Sciences, with fairly neutral scores in the other disciplines. The second cluster includes three of the largest continental European countries (France, Italy and Poland), Hungary and India. These countries have a modest RCA in the Physical Sciences, with a fairly strong comparative disadvantage in the Social Sciences. Japan is also close to this cluster, but is less typical of it as it also has an RCA in the Biomedical Sciences.

Our third and largest group includes Europe's Germanic countries (Austria, Germany and Switzerland) and most of the smaller European countries (Sweden, Finland, Denmark, Ireland and Belgium). These countries show a very balanced profile with no strong comparative advantages or disadvantages. Depending on the individual country, the strongest advantage is in the Biomedical Sciences or in the Environmental Sciences. Greece and Turkey are most similar to each other and, together with Spain, join this cluster in a later step. However, all three are stronger in the Environmental Sciences than in the Biomedical Sciences.

Figure 1



The next cluster consists of the traditional Asian tigers (Singapore, South Korea and Taiwan), joined by Asia's latest fast-growing economy China, and is characterized by a very strong RCA in Engineering, with comparative disadvantages in most other disciplines except for the Physical Sciences. Russia and the Ukraine are mostly similar to each other with a very strong focus on the Physical Sciences.

The last cluster consists of two groups of countries that all share a very strong RCA in the Environmental Sciences. However, the two Latin American countries have a comparative disadvantage in the Social Sciences, whereas Australia, Norway, New Zealand and South Africa also have a RCA in the Social Sciences.

Table 2: Countries categorised into five disciplinary groups (2002-2012 data)

	Major Disciplines					
Group	**Social**	**Bio-med.**	**Phy-sical**	**Engi-neering**	**Environ-ment**	**Countries**
1. Fairly Balanced, Med. Social RCA	**52%**	9%	-13%	-16%	-6%	Netherlands, USA, UK, Canada, Israel
2. Fairly Balanced, Low Physical RCA	-62%	-6%	**30%**	2%	10%	France, Italy, Hungary, India, Poland
3. Balanced	-5%	**11%**	-10%	-15%	**13%**	Austria, Germany, Switzerland, Finland, Ireland, Belgium, Sweden, Denmark
4. High Eng. RCA	-41%	-28%	1%	**101%**	-40%	Singapore, Taiwan, South Korea, China
5. High Physical RCA, Low Eng. RCA	-70%	-68%	**115%**	33%	-40%	Russia, Ukraine
6a. High Environ. RCA	-53%	9%	-7%	-40%	**101%**	Argentina, Brazil
6b. High Environ. RCA, Med. Social RCA	**65%**	-12%	-34%	-33%	**94%**	Australia, Norway, New Zealand, South Africa

Apart from the addition of the Social Sciences, our classification is fairly similar to that reported by Glänzel et al. (2006, 2008). They presented four clusters, the Western model with a focus on medical research (our group 3), the former socialist model with predominance in Chemistry and Physics (our group 5), the Bioenvironmental model (our group 5a), typical for developing countries, and the Japanese model (our group 4), typical for developed Asian countries with a predominance of Engineering and Chemistry. Interestingly, in our study the "Japanese" model is mainly displayed by other Asian countries, as Japan has equally strong – but still very low – RCAs in the Biomedical Sciences and Engineering Sciences and is hence not classified, whereas the Asian tigers have a very strong RCA in the Engineering Sciences, with comparative disadvantage in all other disciplines.

Our findings also largely confirm previous smaller-scale studies. The Australian BIE report positioned Australia, South Africa and Norway in the Environmental Sciences cluster (our group 6b), the smaller European countries in the Medical group (our group 3) and Singapore, South Korea, Taiwan and India in the Engineering group (our cluster 4). However, they did not distinguish a Social Sciences or Physical Sciences group and hence did not classify the USA or large European countries. Kozlowski et al. (1999) already documented the strong focus of Central and Eastern European countries on Physical Sciences. Our results also confirm earlier findings by King (2004) for Russia, France and Germany, and Choung and Hwang (2012) for Korea and Taiwan.

PORTER'S DIAMOND

In this section, Porter's diamond is used to explain individual countries' research profile in specific disciplines. For each group identified in Table 2, we analyse the role of determinants (factor conditions, demand conditions, strategy and rivalry, and related industries) and government in explaining why a country may have a comparative advantage or *dis*advantage in disciplines. Given the large number of countries covered, the analysis limits itself to the presentation of the main factors for the group as a whole, and is not exhaustive.

Group 1 Countries in Group 1 that exhibit the highest RCA for Social Sciences, are composed of the most populous English-speaking countries, the Netherlands and Israel. There are several likely reasons underlying this dominance of English-speaking nations in the Social Sciences. *Factor and Demand Conditions*. Because of the size of their economies and their early dominance on the world stage, demand conditions for professional management were probably more important and sophisticated in the UK and USA than elsewhere. *Strategy and Rivalry.* This means that research in Business & Economics in these countries was able to create a first-mover advantage. This is also reflected in the fact that the USA, followed by the U.K. (in part with the technical assistance of the USA), were the first to establish Business Schools, creating the infrastructure (Knowledge infrastructure as a factor condition) for further research in this area (Tiratsoo, 2004). As a result, a number of early centres of excellence were established in this area of research in the USA and to a lesser extent the UK. Competition and collaboration between these centres further promoted research. *Related Industries.* There are numerous publishing houses and journal publishers in these countries (Related and supporting industries), the presence of which is all the more crucial since many are strong international leaders. These journals only publish in English, a factor condition more readily available in native-English speaking countries. Another reason for English-speaking dependence also lies in the fact that much research in Social Sciences is context-dependent, which will lead many academics in other countries to publish in non-English-language journals, few of which are included in the SSCI. However, there are some indications that this is changing, at least for smaller countries. A recent study of 2000-2009 publication patterns in the Social Sciences and Humanities in the Dutch-speaking part of Belgium (Engels et al., 2012) showed that in Psychology and Economics & Business nearly 90% of publications were in English.[5] It is likely that similar patterns would be found in the Netherlands and Israel, the only non-native-English-speaking countries in this cluster.

Group 2 Countries in Group 2 possess a more balanced set of RCAs, with a low-medium RCA for Physical Sciences (and a strong *dis*advantage for Social Sciences). This group comprises three large European countries (France, Italy and Poland), Hungary and India. *Factor Conditions and Government (or Institutional Support)* The European countries benefit from geographical proximity advantages (factor condition). Leading academics in France and Italy benefit from institutional support from the European Union, for instance through the European Science Foundation programme, which supports cross-country research in the areas of chemistry, mathematics and physics, or through the Astronet programme, a consortium of the largest funding agencies for astronomy in Europe. This supports the idea that to explain countries' advantages, it can be necessary to consider multiple-diamonds, and

[5] In our study, Belgium had the strongest RCA in the Medical Sciences, but also showed RCA in Psychology & Psychiatry and Economics & Business.

the role of supra-national institutions, as discussed in the theoretical section (see Rugman and D'Cruz, 1993).

France is a good illustration of the countries in group 2. Other studies have shown it performs well in both Environmental and Physical sciences (Nature, 2013), which is explained by a continued spending on R&D (at 2.25% of GDP in 2012, France's R&D spending is just above the European average) and the presence of the French National Centre or Scientific Research (CNRS). In 2012, four higher education institutes ranked amongst the world's top 50 for Physical Sciences, namely Ecole Polytechnique, Université Pierre et Marie Curie, Université Paris-Sud and Ecole Normale Supérieure (Times Higher Education, 2013). Importantly, the French national research portfolio has traditionally emphasized Mathematics (Adams, 2011). The strength in Physical Sciences for Poland and Hungary would be explained by factors similar to those presented by countries of group 5.

In the case of India, its research strengths are diverse, but Agricultural Science and Chemistry dominate (Adams et al., 2009), and are related. *Factor Conditions, Strategy and Rivalry, Related Industries.* The chemical industry has been long established in India and was protected until the early 1990. It has contributed to the country's growth through its contribution to downstream industries, notably its specialty chemicals used widely in various industries (such as the food, the pharmaceuticals or the rubber industries). With rising competition, more emphasis is paid on R&D, and India already boasts numerous scientific institutions and a large pool of scientific manpower.

Group 3 More pronounced than is the case of group 2, countries in group 3 present a balanced research profile, with no high RCAs (or *dis*advantage). The group is composed of three (predominantly) German speaking neighboring countries (Germany, Austria and Switzerland), and European small economies (the three neighboring Finland, Sweden and Denmark, as well as Ireland and Belgium). *Factor Conditions.* All these countries benefit from advanced specialised factors such as highly-skilled human capital, knowledge and capital resources (well-funded scientific institutions). These advanced specialized factors are all integral to innovation, reflective of countries with a high level of economic development and wealth. According to the World Bank, most countries in our sample are part of the *High Income Economies* category and are countries that are in stage 3 of innovation-driven development (WEF, 2012), which would support their balanced research profile. Our findings support the notion that with very few exceptions, all leading scientific nations, and in particular smaller ones (that is most of countries in group 3) are world-leading not only overall but also in all individual scientific disciplines (FWF, 2007:6).

Group 4 Countries in Group 4 demonstrate a high RCA for Engineering Sciences; they include Asian Newly-Developed countries (Singapore, Taiwan and South Korea) and China. A number of reasons can be attributed to this advantage in engineering science. *Government.* Since these countries suffer from a relative lack of natural resources, their governments established clear guidelines to promote economic development through manufacturing and export orientation (IMF, 2011), and dedicated substantial financial resources (high capital resources as a factor condition) to R&D, higher education and academic research. All these countries developed competitiveness in electronic and mechanical technologies as one means to achieve economic development (Hobday, 1995; Hemmert, 2012). Advantages in engineering science can therefore be explained by an economic development imperative, with government funding channeled to disciplines linked to economic development objectives.

This highlights the predominant role of government and capital resources (targeted funding) in sciences with a high level of practical application. For instance, the South Korean government provided support to selected large business groups (*chaebols*) as a key pillar in its economic development strategy; *chaebols* have now become major internationally-competitive groups (Samsung, LG, Hyundai and SK are involved in electronics, shipbuilding and automobiles). South Korea recently strengthened its innovation strategy, and amongst OECD countries in 2011 ranked third in terms of gross R&D expenditure (OECD, 2012).

Demand Conditions. Rising numbers of students, in parallel with economic development and government spending in education, as well as private firms' demand and engagement in science-based knowledge production, also explain this group's advantage in engineering science. *Strategy and Rivalry.* Choung and Hwang (2000:421) show strong Industrial collaboration and publications by private firms, namely the large electronics firms in South Korea, or semiconductor firms (such as Mosel-Vitellic, TSMC, UMC and Vanguard International Semiconductors) in Taiwan. Asian latecomer countries thus concentrate on technological knowledge production and industrial technology (Choung and Hwang, 2012). Group 4 reflects the fact that patterns in basic research capabilities are influenced by economic development strategies and the structure of industrial development.

Group 5 This group is composed of the two neighboring countries that are Russia and Ukraine, both of which possess a strong RCA in Physical Sciences. *Factor conditions and Government.* Besides geographical proximity and institutional support, direct government involvement can also be a strong explanation. Ukraine and Russia have been previously shown to be highly productive in Physics (Almeida et al., 2009:137). Interestingly, Matthiessen and Schwarz (1999:459) showed that Moscow and St Petersburg demonstrated high productivity in Physics and Physical Chemistry, indicating a degree of concentration in RCA. Thus, our results are in line with those of other studies showing the predominance of chemistry and physics as a common pattern for former socialist countries (Kozlowski et al., 1999; Schulz and Manganote, 2012:520).

Historically in Russia, Physical Sciences were important in the Academy of Science, with an emphasis on Physico-Mathematical, Chemical and Geological-Geographical Sciences. The pre-1970 priorities (in physics, nuclear energy and chemical engineering) were justified on the basis of a "science push" and "linear model of innovation" framework, those being closely linked to the military-industry complex (Kozlowski et al., 1999:161). In Russia, Ukraine (but also in other Eastern European countries), universities channeled funding to specialisms in line with mission-oriented policies and projects of national significance (often with an emphasis on national defense) (Radosevic, 2002), demonstrating common institutional features inherited from the centrally-planned period and a dominant role of government (Radosevic and Auriol, 1999). RCA in Physics is likely to persist in Russia, since the government remains the main source of funding for Academy of Sciences institutes, which focus on basic research and development.

Groups 6a and 6b Countries in these groups have a high RCA for Environmental Sciences. Group 6a is composed of the two largest South American economies, Argentina and Brazil. Group 6b is composed of three predominantly English-speaking economies (New Zealand, Australia and South Africa) and Norway. Group 6b shows medium RCA in Social Sciences, as well as its high RCA in Environmental Sciences. In the international business literature, they would traditionally be characterised as commodity exporters. *Factor and Demand Conditions.* In Argentina and Brazil, most research has concentrated in the area of life sciences over the past few decades (Garg, 2003:174), yet our data points to a comparative advantage in environmental sciences, which reflects the availability of natural resources and industrial specialization in the countries. Both countries are large in terms of surface area, with high availability of natural resources, arable land, large coastal areas, and an important and rising agricultural-related manufacturing sector.

Countries in groups 6a and 6b share similarities in their export patterns, with over half of their exports in natural resources sectors (e.g. live animals, beverages and tobacco for New Zealand, inedible crude materials, animal and vegetable oils, fats and waxes for South Africa) (World Bank, 2012). Thus, despite differences in levels of economic development and advanced factor conditions, countries in this group benefit from the presence of natural resources. Our position for Norway confirms previous studies (Almeida et al., 2009:137). The country presents particular characteristics, such as a higher relative development in Environment and Ecology, and especially Geosciences, which explain its position in a group with a high RCA for the Environmental Sciences. Most countries in this group have long-established universities with limited competition within the higher education sector, and low to medium involvement by the government in the determination of scientific activities of higher-education institutions. Thus, a high RCA in environment science is strongly linked to the availability of physical basic resources (factor condition) in terms of land, natural resources or country size.

Countries in group 6b present a medium RCA in Social Sciences. Similarities with group 1 in terms of language and ability to publish in English explain this pattern. Australia and South Africa have seen this research profile increase since 1994-2004 (see Table 1), and if this trend continues, these two countries may present a more balanced research profile in the future.

Discussion and Conclusion

Different countries have very different research profiles, and international business theories can be used very effectively to analyse these differences. Our results were based upon 21 disciplines and 34 countries, with a comparison between two key time periods (1994-2004 and 2002-2012). Countries with the largest publication output included the USA, Canada, Japan, China and four European countries (Germany, Italy, France, UK), but this changes significantly when comparing publication output in relation to the size of the country. In this case, small economies move up the ranking. All countries increased their output over time, with some demonstrating a much faster increase – notably developing or newly-developed economies (China, Turkey, South Korea, Singapore and Brazil) showed the fastest increase. Research profiles for individual countries, however, remained very stable when comparing publication output over the two time periods.

We identified groups of countries with similar RCAs in Social Sciences, Physical Sciences, Engineering Sciences, Environmental Sciences or Biomedical Sciences. Using Porter's diamond, we argued that key determinants explain country groupings and specialization. Group 1 has RCA in the Social Sciences. A highly developed knowledge infrastructure (factor condition), first-mover advantage with long-established institutions (strategy and rivalry), sophisticated demand (demand condition) and related industries (such as publishing) were useful in explaining why countries fell in this group. Group 2 comprises countries with an advantage in the Physical Sciences, but a rather balanced research profile. In this case, socio-political factors, historical patterns and strong institutional conditions are key explanations. Group 3 presented a balanced research profile with no strong RCA, and is illustrative of high income economies with advanced specialized factors. Group 4 comprised Asian countries with RCA in the Engineering Sciences. This research profile is explained by high capital resources (factor conditions), universities' goals, rules and incentives (strategy and rivalry), as well as economic development objectives and government support. Group 5 was composed of the two neighboring countries, Russia and Ukraine, with high RCA in Physical Sciences and moderate RCA in Engineering Sciences, where socio-political factors, historical patterns and strong institutional conditions are key explanations. Group 6a and 6b demonstrate high RCA in the Environmental Sciences. Countries within this group benefit from strong natural basic resources linked to high related demand from local industry.

Our analysis highlighted a number of key points. Firstly, we find that to explain scientific advantage in nations, a more complex framework is needed to extend arguments provided in previous studies (e.g. May, 1997; King, 2004; Rousseau and Rousseau, 1998; Inonu, 2003), which focused primarily on country size, economic and financial considerations. Instead, in this paper, we find that a number of key factors should be jointly considered and that a concept borrowed from the international business discipline – Porter's diamond – helps in this approach. Importantly, we have shown that various factors should be distinguished, separating the presence of natural or human resources from capital resources (in the form of government funding), coupled with a distinction between basic and advanced factors. Basic factors refer to availability of natural resources that would explain a specialization and advantages in, say, environmental sciences, whilst advanced factors refer to factors such as knowledge infrastructure available in individual countries. Secondly, our analysis also pointed to the key role played by institutions. Institutional heritage in individual countries, regional institutions (such as the European Union) and the role of national government support and guidance can, in selected cases, be instrumental in explaining the scientific advantage of nations.

It is noticeable in our sample that high-income economies tend to present a balanced research profile, explained by the presence of advanced specialized factors, as well as strong institutional environment. Newly-developed or emerging economies show strong RCA in Engineering Sciences (which as discussed above was historically based upon economic development strategies) or Environmental Sciences (linked to existing natural resources), whilst transition economies can be found to have strong RCA in Physical Sciences. In addition, although all countries increased their scientific output overall, the highest increases occurred in developing and newly-developed countries, mostly in Asia.

To conclude, we show that whilst all four quadrants of the diamond provide explanations behind strength in scientific outputs overall, specific factors vary in the explanation of the scientific advantage of nations, and the role of government is important in a number of cases, although through different means and actions. Combining existing knowledge with the results of this present study, we propose an academic diamond (see Figure 2).

Insert Figure 2 Here

Our results not only provide useful insights into academic performances of countries around the world, but they also point to unique factors that ought to be considered when applying Porter's diamond to academia.

Factor Conditions: describe a country's position in various factors, including human resources (such as the quantity of researchers, skills levels and cost, as well as other labour considerations in relevant industries linked to key advantages), physical and basic resources (such as land/water/mineral, climatic conditions, location of the country and proximity to other countries with similar research profiles, size, etc…), knowledge resources (including universities, government research institutes, private research facilities, government statistical agencies and/or scientific literature), capital resources (cost of capital available to finance academia, including government funding to universities, higher education R&D spending, or private funding for research projects), and infrastructure (telecommunication systems, but also general factors affecting quality of life and attractiveness of the country for skilled academics).

Demand Conditions: represent the size, sophistication and growth pattern of the relevant markets for academic services, from the student population (in terms of teaching/training), other academics in the country (that is number of research active academics in the discipline or in related disciplines), other academics abroad, the private sector (with related demand for training, or researchers in the private sector), which might enhance within-country citations), and both public and private sectors (in terms of future employers of students and qualified labour).

Strategy, Structure and Rivalry: these are the conditions explaining how research institutions are created, organized and managed, including the potential for rivalry amongst those. This include university goals and strategies (research profile, internationalization path in terms of staff, campuses and student body, positioning and key faculties), local rules and incentives (such as salaries, incentives for publication, IP protection, and research-led promotion system), and local competition (that is the number of research universities, research centres, existing research clusters, territorial dynamics, and the rate of creation of new universities which can be important in developing countries).

Related and Supporting Industries: comprise non-HE research institutions, the publication industry, the availability of own language specialist publications, the IT industry, etc.

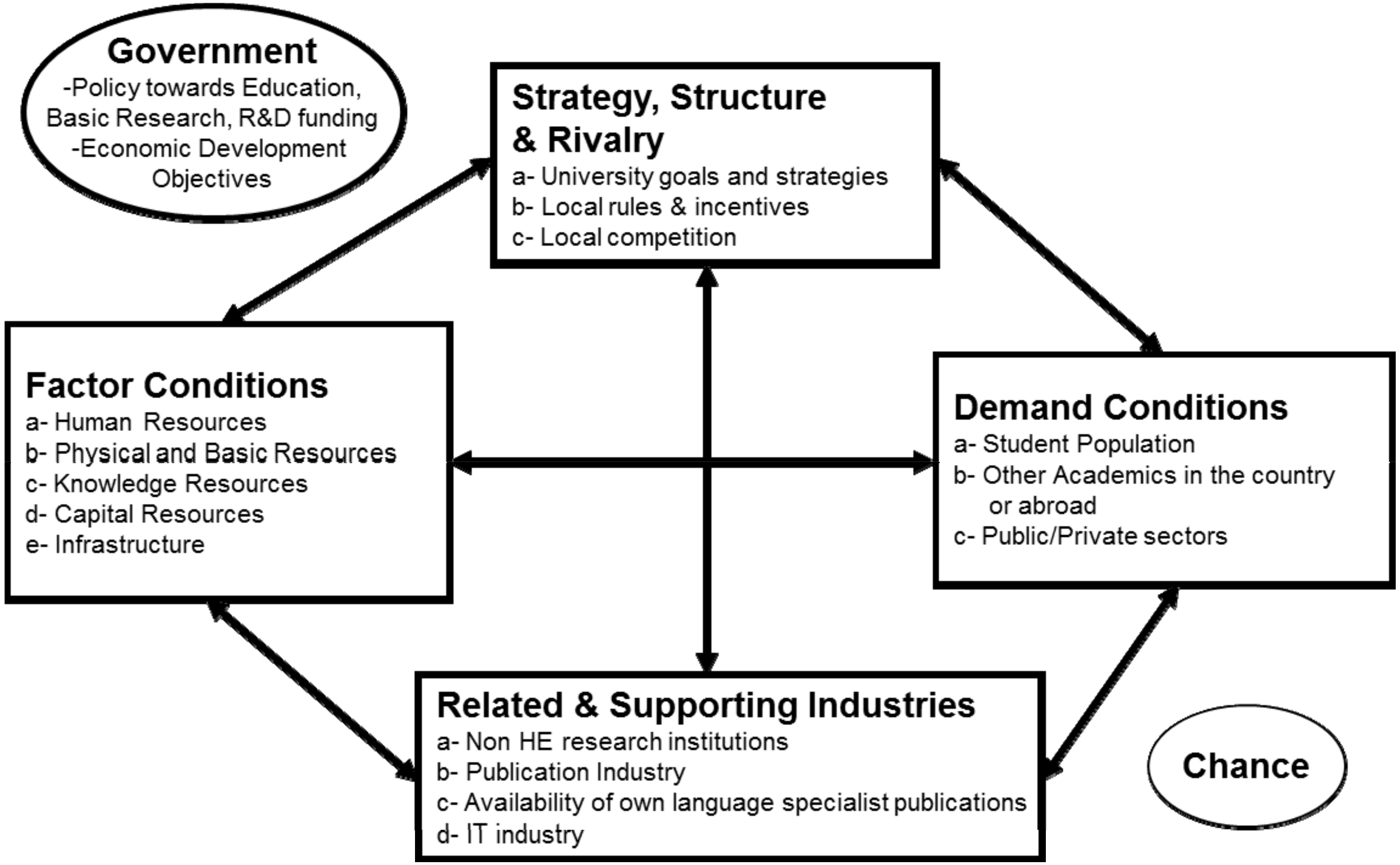
Government: arguably plays an important role in terms of the academic publication profile of a given country. This occurs as a result of a number of policies towards education, basic research or R&D funding, and can also be linked to the economic development objectives of the country.

Chance: is traditionally included in the Diamond, but we acknowledge that its effect can barely be predicted (Porter, 1993).

Application of the generic academic diamond to individual countries ought to include discussion on how advanced factors are built on basic factors (such as the existence of wine universities in France), and differentiate between generalized (telecommunication systems) and specialized factors (existence of specialized scientific institutes with relevant expertise), since the latter are integral to innovation. We note that dynamism applies to factor creation (with investments made in targeted skills), since academia *is* a factor-creation mechanism. However, the research profile of countries tends to be fairly stable over time.

We acknowledge that more research is needed to extend the findings of our work. Notably, the inclusion of a wide range of countries and disciplines limits the ability to include “hard” data on the various factors in Porter’s diamond. Instead, we used a reflective analysis to provide explanations for countries’ scientific advantages. This therefore leads to a call for further research in this area, and one avenue forward can be to engage in cross-disciplinary research and combine insights from economics of science and economics of innovation. In our view, international competition for academic research will continue to intensify, in part because many governments perceive education as an essential means to achieve economic development (such as East Asian economies), whilst boundaries will become more blurred. Firstly, globalization of academia is still in its infancy. With increased movements of research-productive academics worldwide (with top academics moving to the USA, China, Hong Kong and Singapore) and a rapidly increasing stock and diffusion of knowledge, the rise in the level of academic outputs is likely to continue. This contributes further to the globalization of research (with an increase in cross-border research), and of publications (with an increase in international membership on editorial boards and cross-country research projects) (Glänzel et al., 2008; Harzing & Metz, 2013). Secondly, higher-education institutions face increasing international competition, as illustrated by various rankings and the rising need to attract international students as a source of funding. This has also prompted numerous universities to become more global (opening campuses in various countries). Competition also occurs amongst academics themselves, who face growing pressure towards productivity. These trends go hand-in-hand with the rising costs of higher education (both to get educated and to run universities). Finally, many countries consider education as key to development and competitiveness and prosperity, and this explains why we have witnessed competitive upgrading in many countries (e.g. China, India, and Singapore). This means that more countries compete in the pursuit of academic excellence, although our results, as well as those of others such as Zhou et al. (2012), show that BRIC countries do not compete in similar disciplines. Within this context, a better understanding of the roots of academic competitiveness in a dynamic perspective will become more, not less, important.

Figure 2 Academic Diamond



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